THE OKONITE COMPANY

HIGH POWER, LOW NOISE PULSE CAI'ES

Second Quarterly Progress Report
April 15, 1953 to August 15, 1953
Contract No. DA 36-039 SC 42669

HIGH POWER NOISE FREE PULSE CABLE

SECOND QUARTERLY REPORT

May 15, 1953 to August 15, 1953

CONTRACT NO.	DA 36-039 SC 42669
FILE NO.	13259-PH-53-91(3403)
DEPT OF ARMY PROJECT NO.	2006C
PLACED BY:	U. S. Army Signal Corps Engineering Laboratories Fort Monmouth, New Jersey

THE OKONITE COMPANY

PASSAIC, NEW JERSEY

HIGH POWER NOISE FREE PULSE CABLE

SECOND QUARTERLY REPORT

May 15, 1953 - August 15, 1953

I. OBJECT

To design and manufacture pulse cables of 50, 25 and 12-1/2 ohms capable of handling from 5 to 40 megawatts of peak pulse power with a minimum of radiated noise and capable of operating over an ambient temperature range of +55°C to -55°C at a maximum hotspot temperature of 125°C.

CONTRACT NO.	DA 36-039 SC 42669
FILE NO.	13259-PH-53-91(3403)
DEPT. OF ARMY PROJECT NO.	3-26-00-602
SIGNAL CORP. PROJECT NO.	2006C

PREPARED BY: Robert G. Feller

APPROVED BY: Frank Gooding

SECOND QUARTERLY REPORT

High Power, Noise Free Pulse Cable

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III PURPOSE

To provide services, facilities and materials to conduct development leading to the establishing of designs for pulse cables, capable of handling high peak power and exhibiting low noise radiation and fabrication of samples for component testing purposes.

This period has been devoted to the design and fabrication of cable type 2515. Type AI has a butyl type insulation and type BI has a silicone rubber insulation.

IV ABSTRACT

We have continued our work on our slab testing procedure and are now painting both sides of the slab with conducting paint. Using this method, we get a good correlation between the SIC of the slab and the same compound in a finished cable.

The power factor and SIC of 022349A Butyl has been checked over a temperature range from room temperature to 125°C. There is no appreciable change in SIC and the power factor drops slightly.

DC80 Silicone Rubber was also checked. The SIC remains constant while the power factor drops with temperature.

Several trial cures were made on the Silastic Cable before the whole cable was cured. A cure in lead followed by an air oven cure gave the optimum cure according to Dow Corning information.

Tests have been made on type AI-B cable. The results are as follows.

Attenuation/100 ft. at 1 mc.	=	.14 db/100 ft.
Velocity	=	48.9%
Corona Level	=	12,000 volt extinction
Impedance	=	24.4 ohms at 1 mc.
Power Factor	=	.9% at 1 mc.

Cable type AI-A will be completed shortly. This has a semiconducting layer over the inner braid.

The power rating of the cable has been calculated for operation at a single frequency. A weighted attenuation is being calculated to determine the frequency at which the power rating can be obtained.

We are entering an order for a 12-1/2 ohms, type 1215 cable, made with 022349A Butyl and also a 25 ohm Type 2515 cable made with Interchemical 1354 Butyl Compound.

Different types of semiconducting materials are being investigated for use on the 25 ohm silicone cable.

V CONFERENCES

June 22, 1953 - Discussion on Progress of Contract.

Present were Messrs. J. Spergel, M. Tenzer of Squier Laboratory and Messrs. Gooding, Slade and Feller of The Okonite Company. The meeting was held at The Okonite Company, Passaic, N. J. The corona levels obtained on the experimental cables were discussed and it was decided to recheck the values. The use of an interlocking armor for a jacket was discussed.

July 28, 1953 - Present was Mr. Spergel of Squier Laboratory and Messrs. Gooding, Feller, and Waldstein of The Okonite Company.

Mr. Spergel brought pieces of cable to be tested by us in our $Z_{\alpha\beta}$ apparatus over a frequency range up to 10 mc. if possible. The tests were to include

(a) all braids tied together

(b) outer braid isolated from others.

August 21, 1953 - Discussion of Contract.

Present were Messrs. Gooding, Feller and Waldstein of the Okonite Company and Mr. Spergel of Squier Laboratory. The meeting was held at Squier Laboratory. A general discussion on the progress on the contract took place. The problem of a semiconducting material for type BI Silastic cable was discussed. It was agreed to use a .1 usec pulse width for our power rating calculations to obtain weighted attenuation. Also check possibility of coloring Butyl material so that the insulation and semiconducting compound can be easily recognized.

VI FACTUAL DATA

A. Slab Testing

1. Conducting Paint.

a. We have been working on the improvement of our slab testing method and are now painting the slabs to within a sixteenth of an inch of the edge on both sides with aquadag, a conducting paint. The following are an average of the readings on the same slab of DC 80 Silicone rubber at 1.5 mc.

	C uufd.	P.F.%
(1) Unpainted Slab	103.4	.37
(2) Painted on both sides	101.8	.96

If we figure in (1) that the losses due to fringe effect are approximately 5 uufd (Quarterly Report I, Page 10) we have a value of 98.4 uufd. The large increase in power factor due to painting may be explained by the decrease in contact resistance between the electrodes and the surfaces of the slab. It is noted that the use of conducting paint gives a increase in power factor of about three times over the unpainted slabs. (See Quarterly Report #1 for power factors of unpainted slabs). The use of the conducting paint gives a much better correlation between the SIC of a slab of compound and a cable of the same type of material. In checking the power factor of a Butyl insulated cable vs. a slab of Butyl, the power factor of the painted slab is appreciably higher than that of the cable at room temperature.

2. Type 022349A Butyl Slabs.

a. Power Factor Vs. Temperature.

Figure 1(2) shows the variation in Power Factor vs. Temperature of Type 022349A Butyl at 2.0 megacycles. The slab was held at the indicated temperature for a period of two hours. There is a slight decrease in power factor as the temperature is raised from 22°C

to 100°C. The high power factor at room temperature does not compare with the completed cable at room temperature. A similar check is being made on the completed Butyl cable.

b. Dielectric Constant Vs. Temperature.

The SIC of the Butyl shows no appreciable change over the temperature range. Figure 2(2)

3. Type DC 80 Silicone Rubber

a. Power Factor vs. Temperature

Tests similar to those on the Butyl were also conducted on the DC 80 Silicone Rubber. Figure 3(2) shows the power factor vs. temperature. It should be noted that there is a decided decrease in power factor as the temperature increases. One reason probably is that the Silastic slab had only one cure prior to the test. Gases are occluded in this type of compound and are released by a slow heat cycle in a dry oven. This test is still being carried on at 125°C. Upon completion, a similar run over the same temperature range will be made on the Silastic cable.

b. Dielectric Constant Vs. Temperature

Figure 4(2) shows very good stability in the dielectric constant over the temperature range at which it was tested.

B. Type BI DC 80 Silicone Rubber Cable.

1. Discussion of Progress

During this quarter type BI cable was completed to the point where the insulation was applied. At this point trial cures were made of short lengths of the cable to give the best cure possible and hence the lowest power factor consistent with physical strength. Short lengths of the cable were first cured in lead in a steam vulcanizer to force the compound into the braid and hence reduce any corona that might occur. Then the lead was stripped and a second cure in an electric oven was made to give the

desired final cure. It should be pointed out that silicone rubber has a peculiar curing schedule. It must be raised to about 490°F to set the compound. This must be done slowly in order to drive off volatile gases in the compound. From data on DC 80 Silicone Rubber supplied by Dow Corning a tensile strength in the neighborhood of 720 lbs/in.^{2} is possible on the final cure.

a. First Trial Cure.

Two short lengths of uncured cable were precured in lead as follows.

(1) One way valves were placed on each end of both samples. "A" was placed in a steam vulcanizer for a 275°F-5 min. cure. "B" was given a 275°F-10 min. cure. The results:

Sample	Tensile #/in.^{2}	Elongation (2")
A	1095	15.4
B	1055	15.4

These results show little difference between the two. Samples A and B were both undercured at this point. They were then placed in an electric oven and raised in equal steps to 490°F in 12 hours. The results were as follows.

Sample	Tensile #/in.^{2}	Elongation (2")
A	370	8.1
B	366	7.7

This low tensile was brought about by too rapid an increase in temperature to 492°F.

b. Second Trial Cure

Two more samples were cured in steam vulcanizer. Sample C at 275°F for 5 min., Sample D at 258°F for 80 min., 20 minute rise, 20 minutes blowoff in the large vulcanizer in the factory. Previous tests were made in a small laboratory vulcanizer. The results are as follows:

Sample	Tensile #/In.^{2}	Elongation(2")
C	1090	15.2
D	961	15.6

It was noted that Sample D appeared quite similar to those cured in the laboratory. These samples were placed in the electric oven and the temperature raised from 200°F to 492°F in a 24 hour cycle and held at 492°F for 15 min.

Sample	Tensile #/In.^{2}	Elongation (2")
C	419	6.2
D	357	5.7

The examination of these samples indicated brittleness and probable overcure.

c. Trial Three

Sample E was cured at 258°F for 80 min. as in the last trial and the lead stripped, then placed in the electric oven. This was given the following cure.

300°F for 5 min.

325°F for 5 min.

350°F for 10 min.

then 10° increments every 10 minutes to 400°F for 20 minutes.

This gave the following results.

Sample	Tensile #/In.^{2}	Elongation (2")
E	632	13.1

This cable seemed quite close to the desired cure and it was decided to cure the entire length as in trial #3.

d. Final Cable Cure (Type B.1)

(1) The ends of the cable were sealed with one way valves and it was placed in the vulcanizer for a 258°F 80 minute cure (20 minute rise 20 minutes blowoff). The results are as follows:

Sample	Tensile #/In.^{2}	Elongation (2")
Cable	927	15.6

(2) The cable was then stripped of lead and placed in the electric oven for the cure described in the third trial. The result -

Sample	Tensile #/In.^{2}	Elongation (2")
Type B1 Cable	777	14.0

This cable when tested at 1.5 megacycles has the following values on a five foot length,

SIC	P.F.%	Z_o (ohms)
3.19	.465%	23.4

when a braid was placed over the insulation.

(3) This cable is in braiding at present. We are working on a conducting paint to be applied under the outer braid. Figure 5(2) give Data concerning the Preparation of Semiconducting Films using Silicone Resins and Carbon Black. We are considering the use of DC 803 Resin with Shawinigan acetylene Black in a mixture of 10 pints of black to 100 pts. of resin solid. It should be pointed out that over a period of time this type of conducting paint will migrate into the silicone rubber with deteriorating effects. We have written to Dow Corning concerning a new type of conducting paint which is said not to have this effect.

C. Type AI-B (2515) 022349A Butyl Cable.

1. Discussion of Progress.

During this period Item B of Cable Type AI was completed. (See Quarterly Report I Page 33 for complete description). This was the Butyl type cable with no semiconducting compound over the inner conductor.

2. Tests

a. Attenuation.

Figure 6(2) shows the attenuation setup that we used to test our cable. By shorting the far end of the cable we measure the odd multiples of quarter wavelengths by changing the frequency over the points of resonance. This is known as the susceptance variation method of test. By using the following formulas the attenuation in decibels per 100 ft. can be computed.

$$\text{Attenuation (db/100 ft.)} = \frac{682}{l} \; \frac{\Delta f}{fr} \quad N$$

Where l = length of cable in feet

fr = resonant freq. in megacycles

Δf = megacycles between 1/2 power points.

N = number of 1/4 wave lengths under test.

With this cable we carried out the attenuation versus frequency measurements up to 9 quarter wavelengths. Figure 7(2) shows the attenuation vs. frequency of type AI-B Butyl cable.

b. Velocity and Characteristic Impedance.

The attenuation measurements were made on two lengths of this cable, (a) 147 ft. and (b) 112.6 ft. after samples had been removed from (a). An average velocity of 49.8% was obtained on (a) while on (b) 54.5% velocity was obtained. Using physical dimensions and capacity per foot measurement

$$L = 140 \log_{10}\frac{D}{d} \text{ uh/1000 ft.}$$

where d = diameter of cable over inner conductor

D = diameter of cable over insulation

$$L = 140 \log_{10} \frac{.93}{.46}$$

$$L = 47.7 \text{ uh/1000 ft.}$$

$$C = .0848 \text{ ufd./1000 ft.}$$

therefore $Z_o = \left(\frac{L}{C}\right)^{1/2} = \left(\frac{47.7}{.0848}\right)^{1/2} = 23.7$ ohms

Using the velocities obtained above

Length	Velocity (%)	Z_0(ohms)
147.6'	49.8	24.4
112.6	54.5	22.0

where $Z_0 = \frac{101600}{\% \text{ Velocity} \times \text{Cuufd./ft.}}$ ohms

The method in which the inductance is figured from the dimensions has been quite accurate in the past. We are investigating the variation in the velocities of the two lengths. By comparison of the SIC values obtained on a three foot sample and the SIC computed from the velocity it would appear that the velocity of 49.8% is the more reasonable figure.

Cable	Velocity (%)	SIC
A (147.6 ft.)	49.8%	4.15
B (112.6 ft.)	54.4%	3.43
3 ft. length	--	3.56

c. Effect of Semiconducting Compound on SIC.

The capacity of a three foot sample of the above butyl cable was checked before the semiconducting layer was applied. The resultant capacity was 85.6uufd./ft. Upon completion of the cable the capacity was checked again and a value of 84.8uufd./ft. was obtained. It can be seen that the presence of the semiconducting material under the outer braid decreases the capacity of the sample only slightly and hence does not change the SIC.

d. Cable SIC and Insulation SIC

It should be pointed out that there are two SIC values obtainable on a cable. From the formula

$$SIC = 136\ C \log_{10} \frac{D}{d}$$

where C = capacity ufd./1000 ft.

D = diameter under outer braid or over insulation

d = diameter over inner braid.

The value given to D will in one case give a "cable" SIC if the diameter under the outer braid is used. If the semiconducting compound has a high capacity and does not lower the overall capacity of the cable appreciably the SIC of the insulation can be obtained by using the diameter over the insulation only for the value of D over the insulation. Figure 8(2) and 9(2) show the SIC obtained by these two methods.

e. Separation of Losses.

We have separated the losses into the copper losses and the dielectric loss. Attenuation may be expressed by

$$\text{Attenuation db/100 ft.} = \frac{4.35\,R_{ac}}{Z_o} + 2.78\,(SIC)^{1/2}\,(PF)\,(f)$$

where R_{ac} = total A.C. resistance in ohms for 100 foot loop

Z_o = characteristic impedance in ohms

f = frequency in megacycles.

We found the SIC from the velocity

$$\%\ \text{Velocity} = \frac{100}{SIC^{1/2}}$$

On a five foot length of cable we measured the capacity and conductance of the sample of a range from .5 mc to 9 mc using the circuit shown in Quarterly Report #1 page 23. From these measurements the power factor vs. frequency curve can be calculated. Figure 10(2).

Using the SIC and P.F. obtained from Figure 10(2), the loss in the dielectric was calculated and then subtracted from the total attenuation to give the copper loss. Figure 9(2).

From Figure 11(2) it can be seen that the copper losses play a dominant role up to two megacycles where the loss in the dielectric takes over. This shows that a low power factor compound is essential for low attenuation at a high frequency and also that it is necessary to keep the copper losses to a minimum over the entire frequency range.

f. Corona Level

Three five foot sections were cut from the reel and tested.

Figure 12(2) shows the apparatus used in testing these cables.

Sample	Initial Corona Volt	Extinction Corona Volt
A	10,500	8,500
B	13,500	11,500
C	13,500	8,500
Average	12,500	9,500

These are the actual corona values of the completed cable. It should be pointed out that these are rms voltages and if corrected to peak values.

Peak Corona

Sample	Initial Volt	Extinction Volt
A	14,850	12,000
B	19,100	16,200
C	19,100	12,000
Average	17,700	13,500

A five foot sample was cut from a piece of cable which had a heat cycle with up to 168°F on the conductor, 185 amps for 12 hours.

Initial Volt (peak)	Extinction Volt (peak)
19,100	12,000

In view of these results we are doubtful about the elimination of the inner semiconducting compound. A check is being made as to where the corona occurs.

g. Power Rating

Figure 13(2) shows the test setup for determining the power rating of Type AI-B cable. A 17-1/2 foot sample was used for the test. The current was supplied by a low voltage current transformer and the power dissipated in the cable measured as indicated in the drawing. Several different currents were passed along the inner conductor and back on

the outer conductor. The ambient, power consumed, D.C. resistance of the inner conductor were measured. From the use of the variation in resistance with temperature, the temperature of the inner braid conductor could be calculated, Figure 14(2). Figure 15(2) shows the 60 cycle watts/ft. dissipated in the cable versus the temperature on the inner conductor at 34°C ambient. From this curve a dissipation of 19.2 watts/ft. will give a 125°C temperature on the inner conductor in a 34°C ambient. If the ambient is increased to 55°C a dissipation of only 14.8 watts/ft. would give a 125°C temperature on the inner conductor of the cable. To figure the power rating of the cable at the operating frequencies the following method was used. It has been established that a 19.2 watts/ft. dissipation will give 125°C on the center conductor at 34°C ambient. Therefore, this must be also true at the operating frequencies. From Figure 7(2) the attenuation can be determined,

$$\alpha(\text{db}/100\text{ ft.}) = 10 \log_{10} \frac{P\text{ in}}{P\text{ out}} \qquad (1)$$

$$\text{Antilog} \left(\frac{\alpha}{10}\right) = \frac{P\text{ in}}{P\text{ out}} \qquad (2)$$

$$P\text{ in} - P\text{ out} = 1900 \qquad (3)$$

$$P\text{in} - \frac{P\text{in}}{\text{Antilog}\left(\frac{\alpha}{10}\right)} = 1900 \qquad (4)$$

$$P\text{in} = \frac{1900}{1 - \frac{1}{\text{Antilog}\ \frac{10}{\alpha}}} \qquad (5)$$

and equation (5) will express the power input that will give a 125°C temperature on the inner conductor at 35°C for a given attenuation. Figuring a .002 duty cycle would mean that the average of 20,000 watts was dissipated. Hence if a weighted attenuation could be obtained for the particular waveform used, one would merely pick out the intersection

of the frequency of the weighted attenuation and the 20,000 watts maximum. If this fell below 19.2 watts/ft., the cable could be successfully operated. To determine the rating for an ambient of 55°C a proportion was set up.

$$\frac{\text{Temp. rise (A)}}{\text{Watts/ft. (A)}} = \frac{\text{Temp. rise (B)}}{\text{Watts/ft. (B)}}$$

So for an ambient of 55°C with a maximum hot spot temperature of 125°C on the conductor

$$\frac{90^{\circ}\text{C}}{192 \text{ watts/ft.}} = \frac{70^{\circ}\text{C}}{X \text{ watts/ft.}}$$

$$X = \frac{(70)(19.2)}{90}$$

$$X = 14.8 \text{ watts/ft.}$$

Thus 14.8 watts/ft. dissipation will give a 125°C temperature on the center conductor. Figure 16(2) shows the power rating at a 34°C and a 55°C ambient. The next step in this program is to determine a weighted average attenuation so that the frequency at which the total weighted attenuation is applied can be found. Knowing this the power rating of the cable can be determined by use of Figure 16(2). We are in the process of determining this weighted attenuation.

h. Power Factor Vs. Time at 125°C.

A short length of cable was placed in an oven at 125°C and the power factor taken over a period of 18 days, Figure 17(2). This shows a decrease for about 10 days, when it levels off. At the end of 15 days the jacket cracked and was noted to be very brittle. The Butyl appeared to be in very good condition. The cable was removed and after standing in air for a period of 8 days still had a power factor of .7% at .5 mc. This indicated that the cure time of the Butyl was not sufficient and should be increased to give a lower power factor compound. The physicals of this cable are as follows.

022349A Butyl Insulation

	Tensile #/In.^{2}	Elongation (2")
Unaged	715	11.4
Aged 14 days at 125°C	642	7.85

Semiconducting Compound

	Tensile #/In.^{2}	Elongation (2")
Unaged	1320	7.7
Aged 14 days at 125°C	1192	4.9

Overall Jacket

	Tensile #/In.^{2}	Elongation (2")
Unaged	4310	13.3
Aged 14 days at 125°C	Brittle and cracked	

From these results it appears that the Butyl will work at 125°C and also the semiconducting compound. The jacket however will not withstand this temperature.

D. Transfer Impedance

Some work has been done in conjunction with Mr. Spergel of Squier Laboratories. We have tested several cables using the circuits shown in Figure 18(2) and 19(2). We have on order some copper tubes with thin walls that we will be able to check our apparatus. The complete results are being held until these tubes are obtained and the apparatus is found to be correct. All connections are made with type 874 General Radio connectors. The cable is enclosed in a copper tube (I.D. = 2") as shown and provisions made for termination of the cable with 50 ohms. The pipe is broken at each end. First to allow the signal to be fed in, and at the other end to allow the 1 ohm resistor to be inserted in the circuit. A more detailed description and explanation will be included in the next report when we will have data on the copper tubes which can be used as a standard reference. (See Bell Laboratory Report. File 36676-5 Sept. 23, 1946-3430-EFV-HH for a more detailed discussion.)

E. Interchemical Corporation.

Type 1354 Compound.

We have received permission to try type 1354 Butyl compound developed by Interchemical Corporation. Dr. Radi of Interchemical has sent the formulation of this compound to The Okonite Company and we are planning to use the compound on Type 2515 cable, a 25 ohms, 15 KV, 10 megawatt cable. This order is being entered and will be in the factory as soon as the materials for the compound have been obtained.

VII CONCLUSIONS

1. It has been decided to use conducting paint of both sides of all slabs to be tested.
2. The SIC of type 022349A Butyl rubber is 3.55 at 1.5 mc. (From cable AI-B)
3. Type 052153E Semiconducting Butyl appears very good at 125°C and 0°F.
4. Corona level of cable AI-B is on borderline.
5. Type 022349A Butyl is O.K. in 125° Test after 14 days.
6. Okocord jacket no good at 125°C.
7. Type AI-B cable power rating appears sufficient for 10 megawatt rating.
8. Type 2515 cable to be made with Interchemical type 1354 Butyl compound.

VIII PROGRAM FOR NEXT INTERVAL

1. Tests on experimental pulse cables when completed.
2. Tests on 15 mil copper tubing with transfer impedance apparatus.
3. Enter order for type 1215 cable made with 022349A Butyl.
4. Enter order using Type 1354 Interchemical Compound on Type 2515 cable.
5. Check cold temperature effect on Butyl.
6. Check on semiconducting compound for silastic rubber.
7. Investigate a Butyl type jacket material.

IX IDENTIFICATION OF KEY PERSONNEL

(See Quarterly Report No. 1)

Morris Weldstein (Summer Help)

Graduated from N. Y. U. 1937 B.S. in Physics and Math.

Graduated from N. Y. U. 1940 M.S. in Physics.

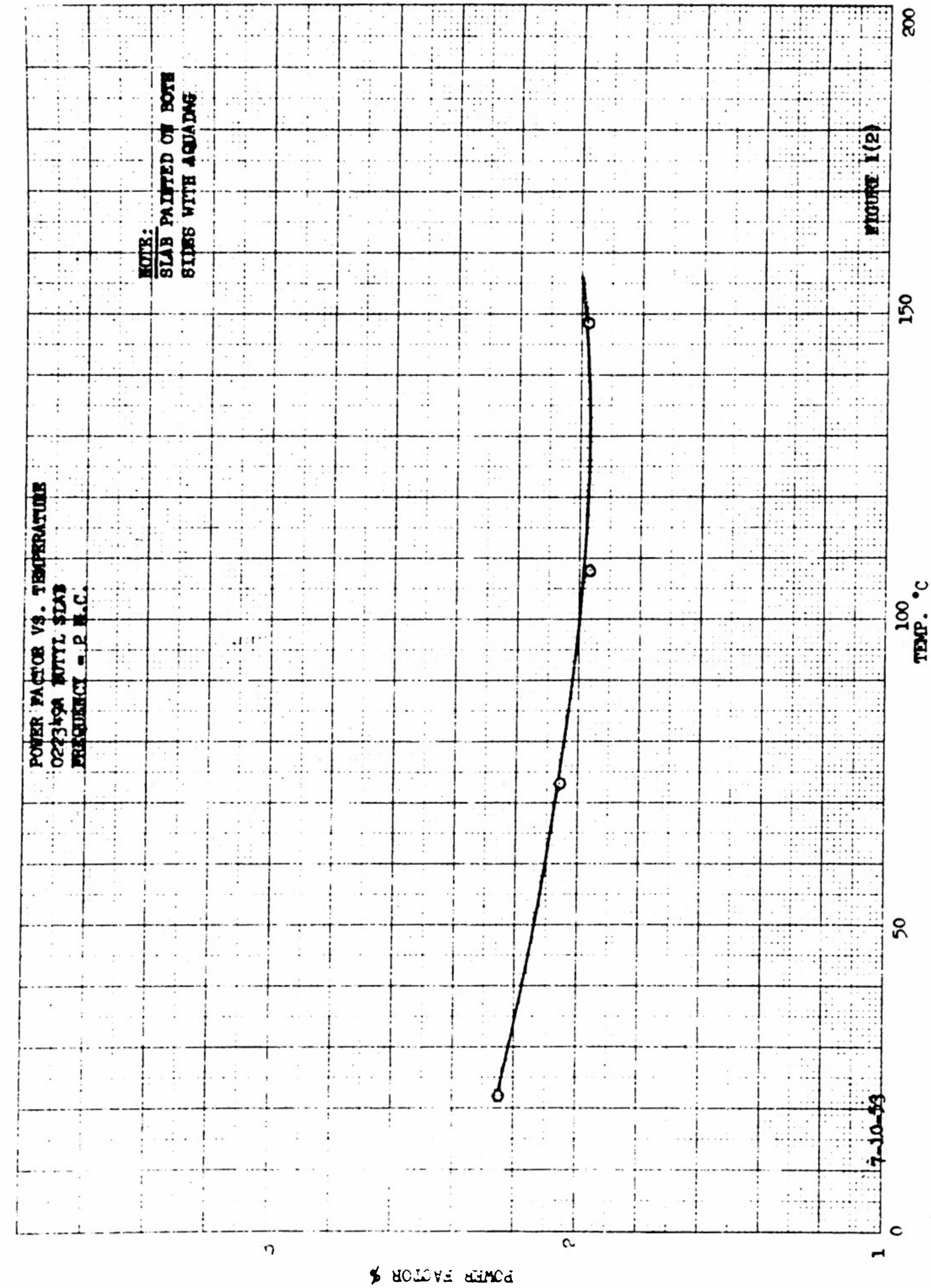
Teacher of High School Physics and other Sciences for 15 years.

Teacher of College Physics (Evening) for 8 years.

X TIME RECORD

Time Spent on Contract to Date

F. H. Gooding	149 hours
H. B. Slade	21 hours
R. G. Feller	419 hours
Laboratory Technicians	458 hours


POWER FACTOR VS. TEMPERATURE
022349A BUTYL SLAB
FREQUENCY = 2 M.C.
NOTE:
SLAB PAINTED ON BOTH
SIDES WITH AQUADAG
FIGURE 1(2)
7-10-53
0
50
100
150
200
TEMP. °C
1
2
3
POWER FACTOR %

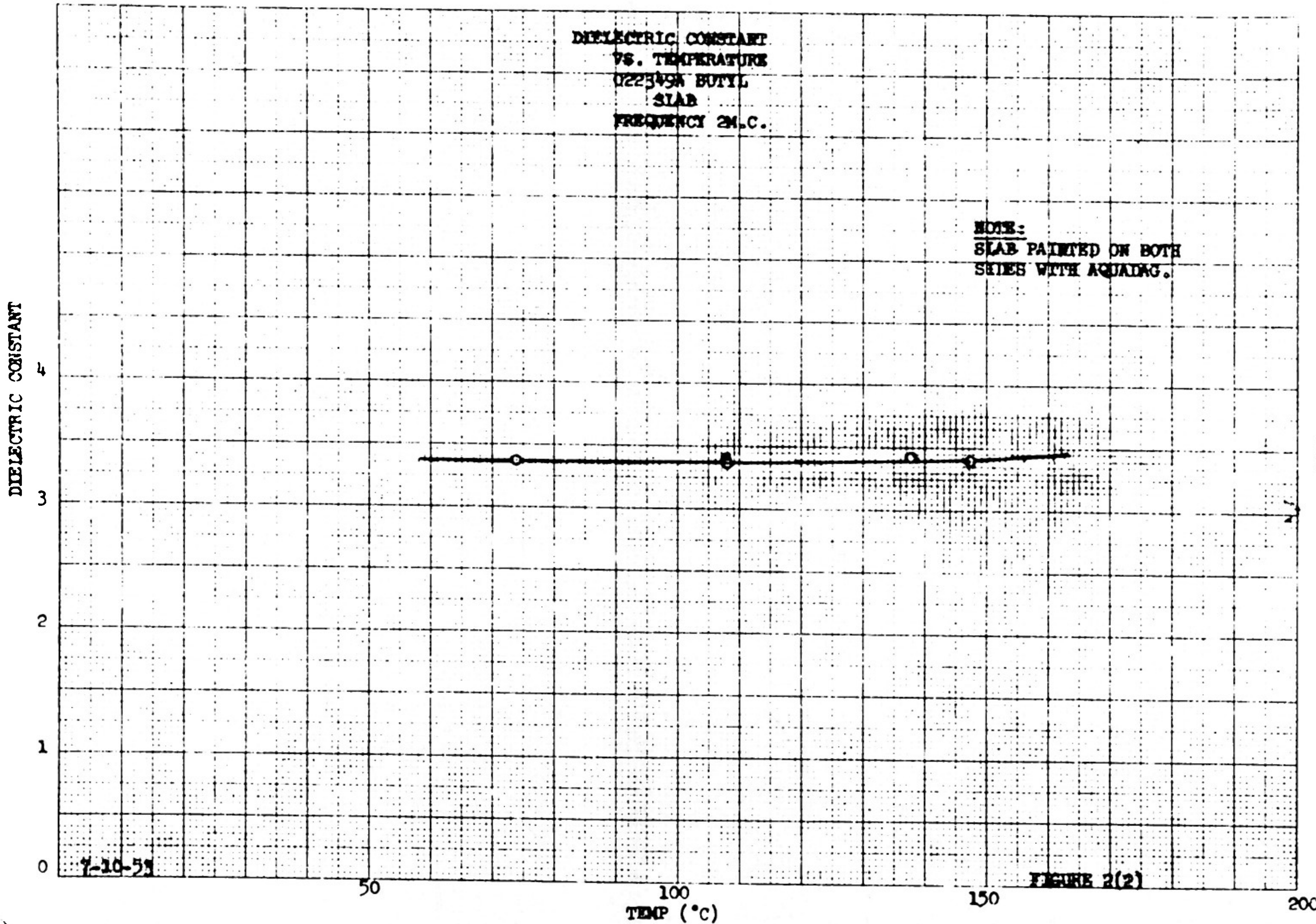
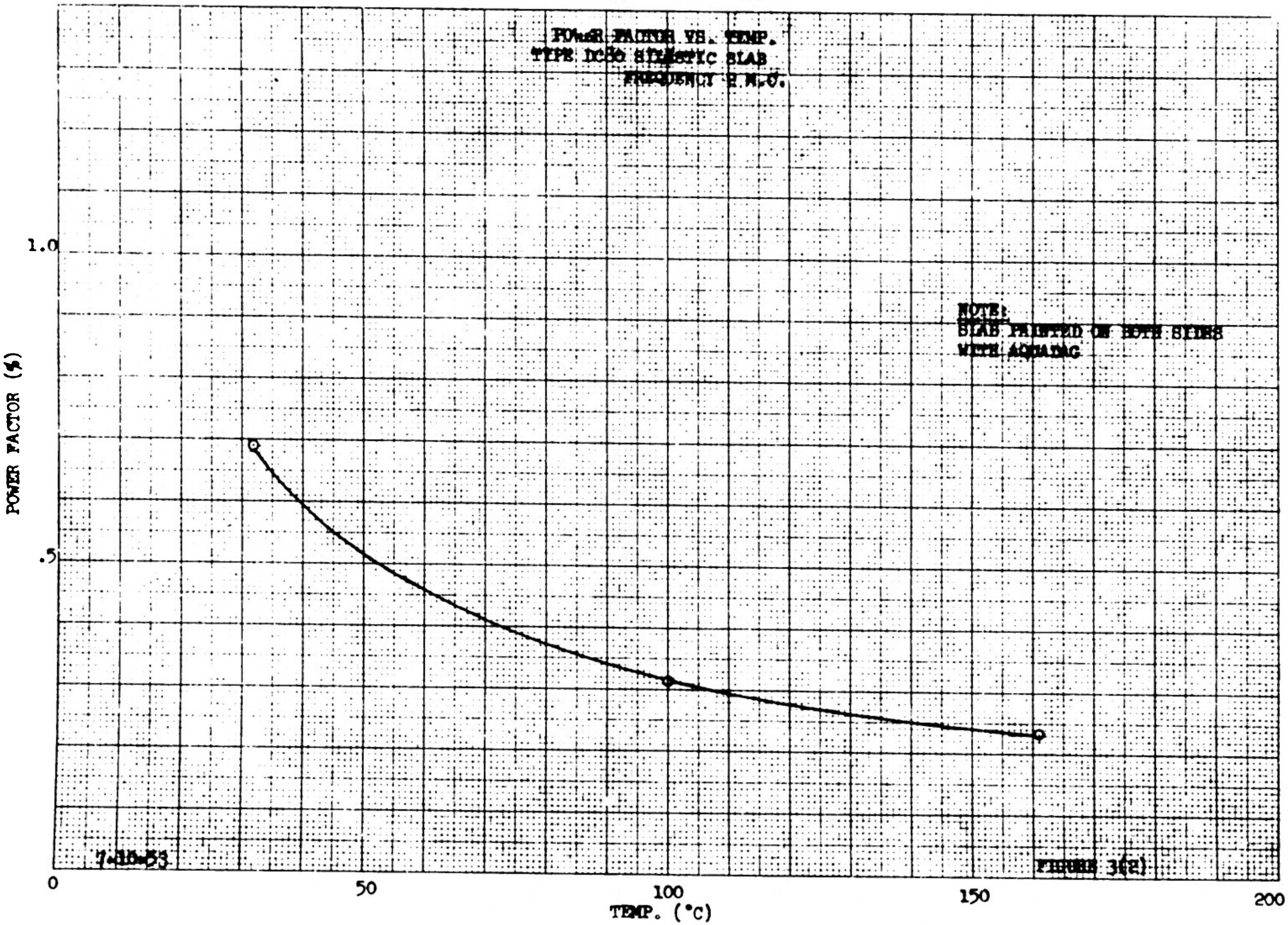

DIELECTRIC CONSTANT
VS. TEMPERATURE
022349A BUTYL
SLAB
FREQUENCY 2M.C.
NOTE:
SLAB PAINTED ON BOTH
SIDES WITH AQUADAG.
DIELECTRIC CONSTANT
0
1
2
3
4
50
100
150
200
TEMP (°C)
7-10-53

FIGURE 2(2)


POWER FACTOR VS. TEMP.
TYPE DC50 SILASTIC SLAB
NOTE:
SLAB PAINTED ON BOTH SIDES
WITH AQUADAG
POWER FACTOR (%)
1.0
.5
0
50
100
150
200
TEMP. (°C)
FIGURE 3(2)

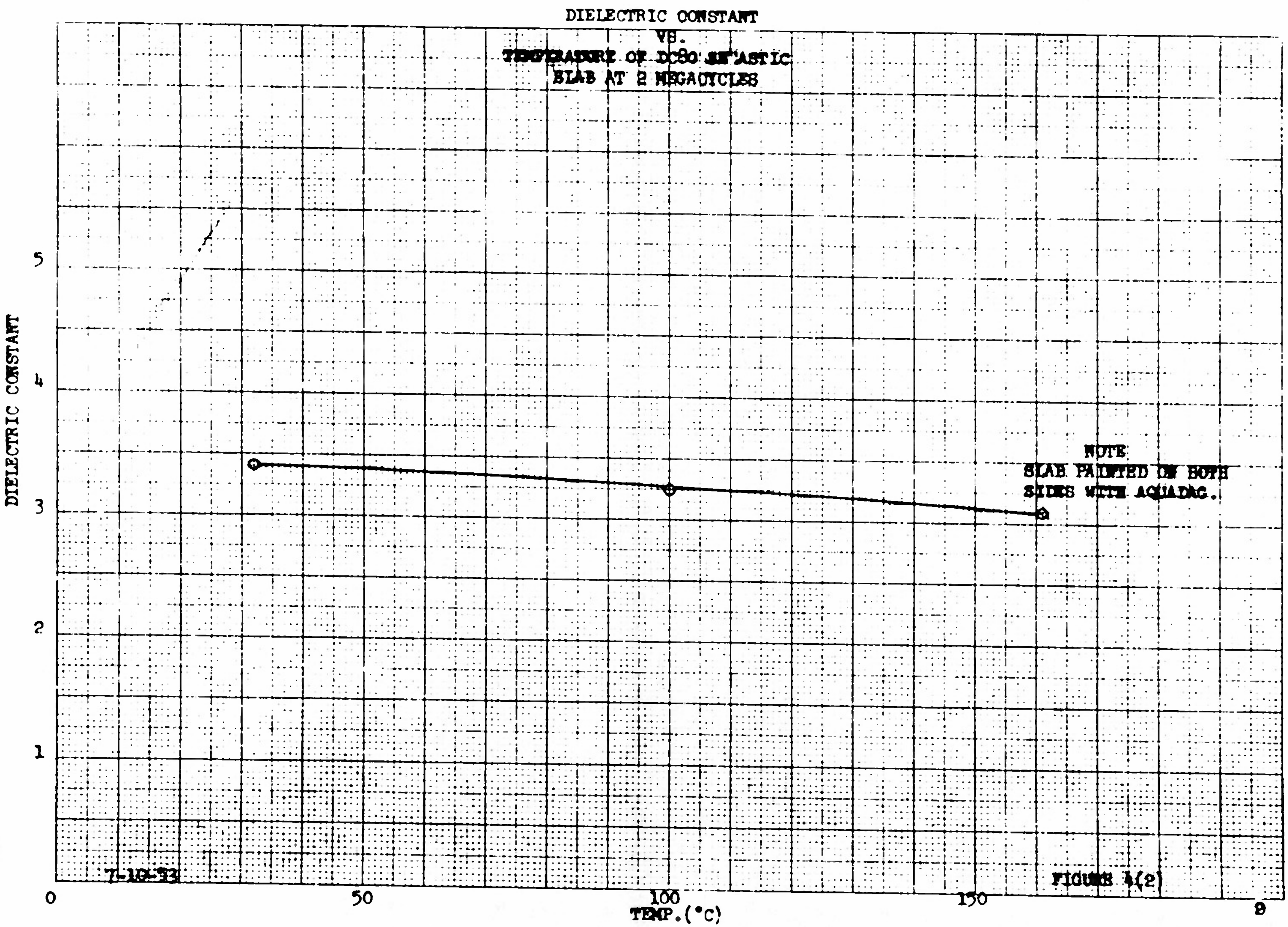

DIELECTRIC CONSTANT
VS.
TEMPERATURE OF DC80 ELASTIC
SLAB AT 2 MEGACYCLES
NOTE
SLAB PAINTED ON BOTH
SIDES WITH AQUADAG.
DIELECTRIC CONSTANT
1
2
3
4
5
0
50
100
150
TEMP. (°C)
7-10-53

FIGURE 4(2)

DATA CONCERNING THE PREPARATION OF SEMI-CONDUCTING FILMS USING SILICONE RESINS AND CARBON BLACK

Mixtures using DC 996 and DC 803 with Shawinigan acetylene black (Shawinigan of Canada, Ltd.) have been made. The black is stirred into the resin by hand for best results. Glass slides 1" x 2" x 1/32" were dipped in the solution, air dryed, and cured one hour at 250°C. Resistance of the film was measured between silver strips painted around the slides and spaced 1" apart.

Resin	Pts. of Black per 100 pts. resin solids	Resistance between electrodes in ohms
DC 996	10	1000
DC 996	10	450
DC 803	20	384
DC 803	20	270
DC 803	10	333
DC 803	10	329
DC 803	5	4750
DC 803	5	3330
DC 803	5	2320

Similar slides were made using micronized graphite:

DC 996	20	Infinite
DC 996	20	"
DC 803	10	10.2×10^6
DC 803	10	1.5×10^6
DC 803	20	22000
DC 803	20	15400

It is evident that the Shawinigan acetylene black is the best for low resistance coatings. There are indications that the resistance will increase somewhat with aging at high temperature, but apparently changes little when subjected to high relative humidity conditions. There are little data to substantiate these conclusions, however. If small changes in resistance are important, the particular formulation should be checked. The resistance will also be affected by the type and amount of mixing used. A well mixed solution will have a higher resistance than one that has the carbon stirred in by hand.

The physical properties of the films are good. Most of them are hard and tough.

Figure 5(2)

ANTENUATION MEASUREMENTS

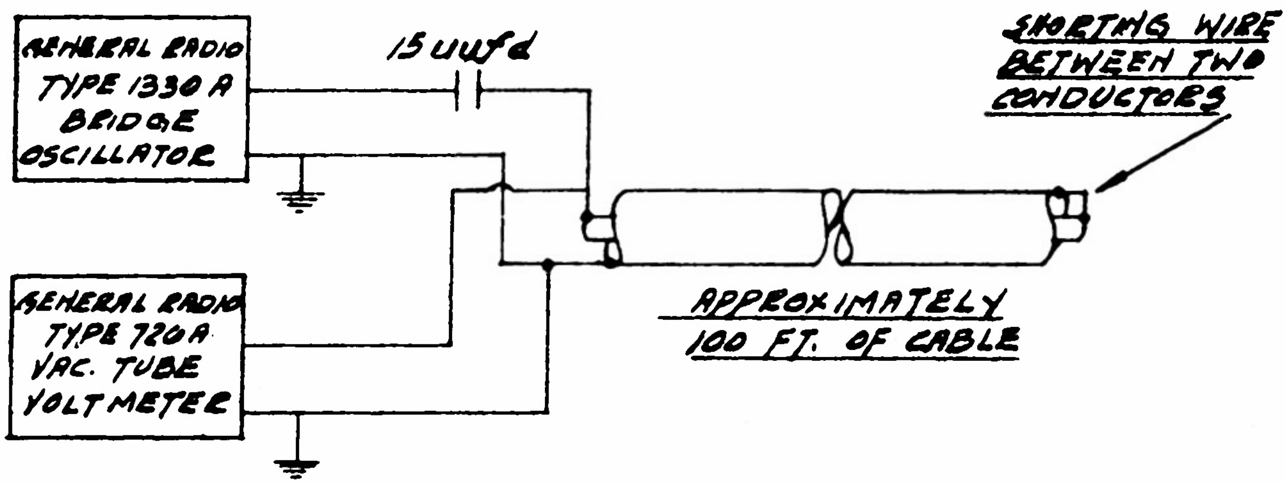
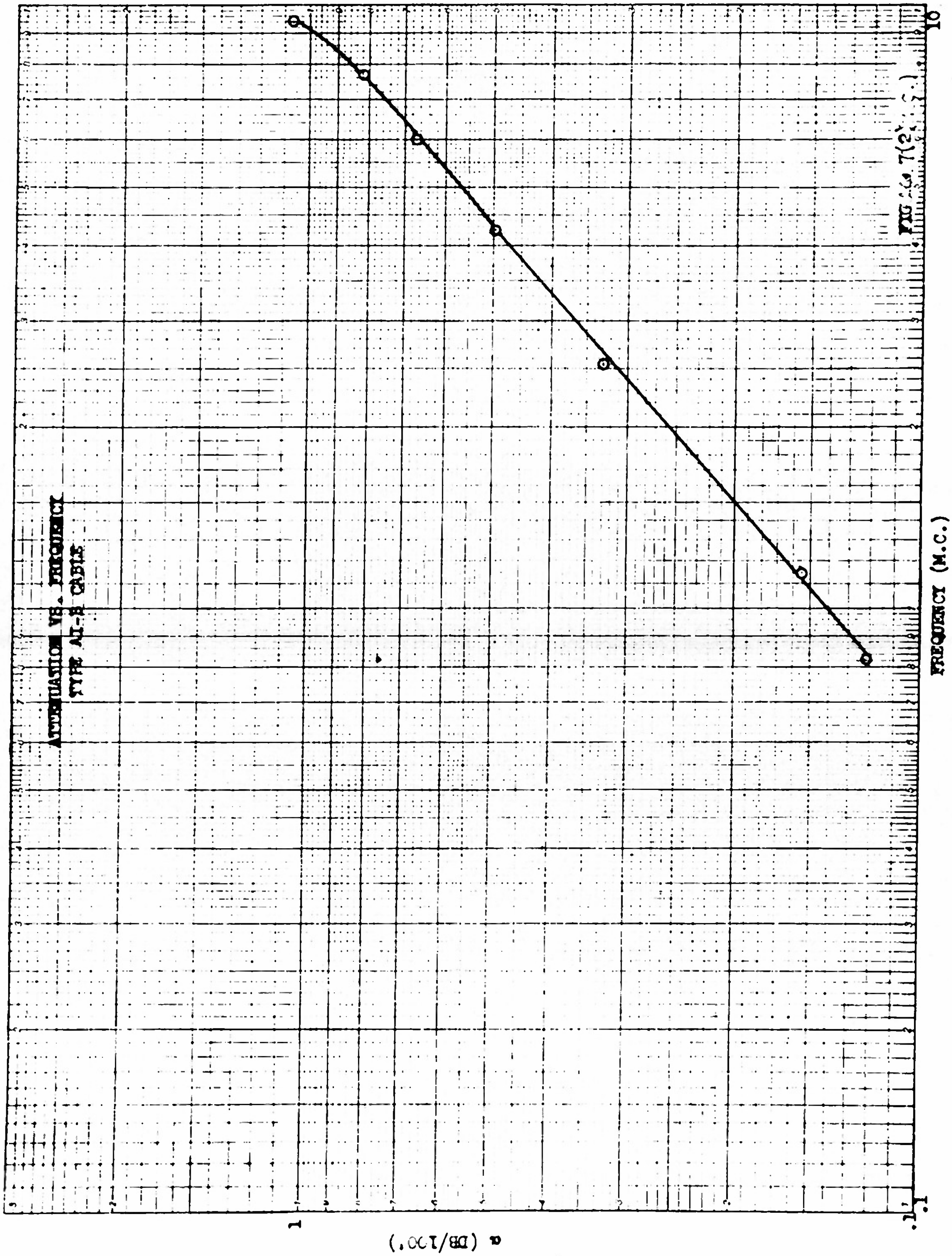


FIGURE 6 (2)

THE OKONITE COMPANY AND THE OKONITE - CALLENDER CABLE CO. INC. PASSAIC, N. J., U. S. A.	DATE 7-11-53 DR. DVI CH.	SCALE — TR. APP.	REVISIONS DRAWING NO. D-3977


ATTENUATION VS. FREQUENCY
TYPE AI-8 CABLE
FIG. 7(2)
FREQUENCY (M.C.)
α (DB/100')
1
10
.1

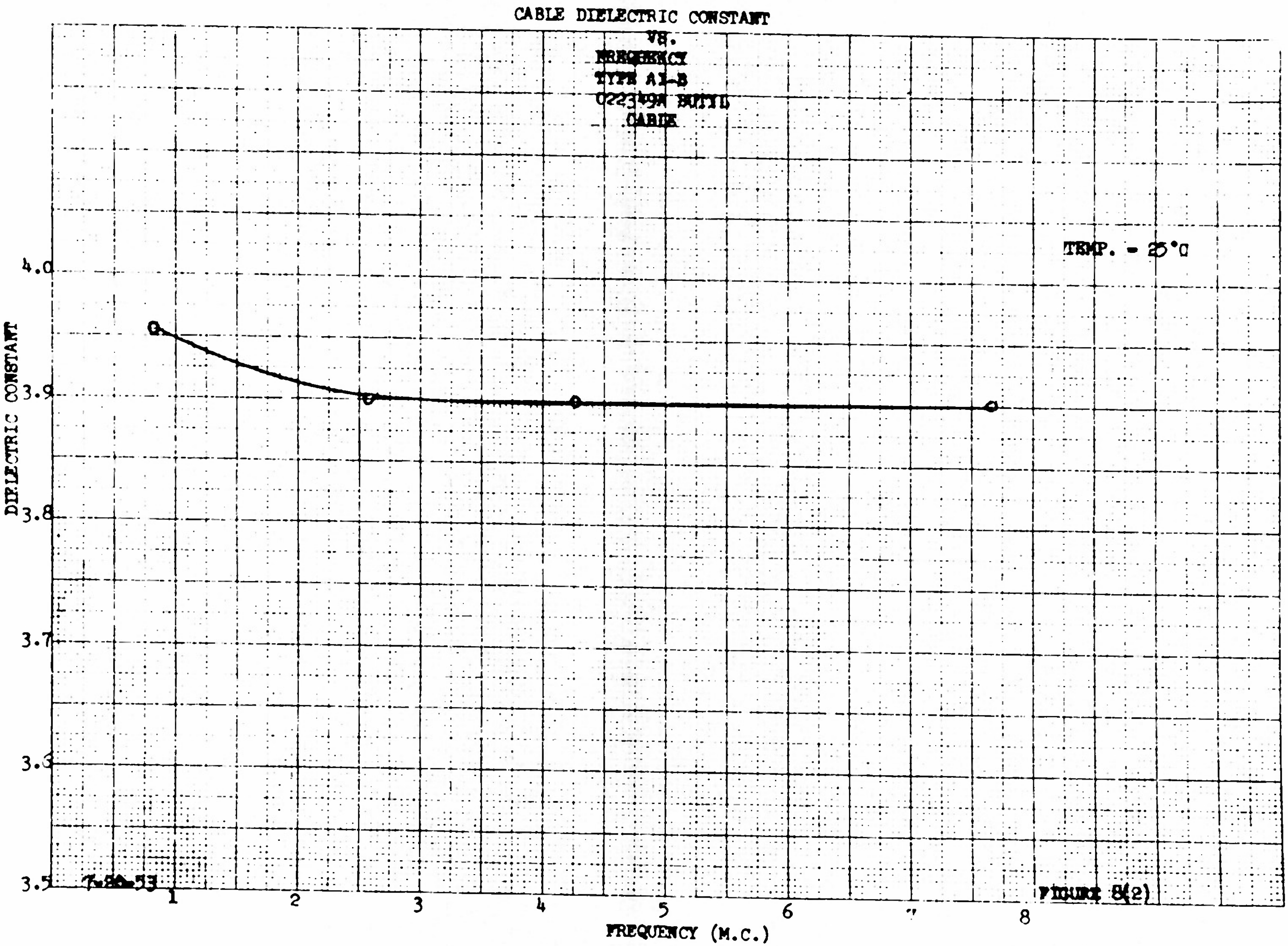
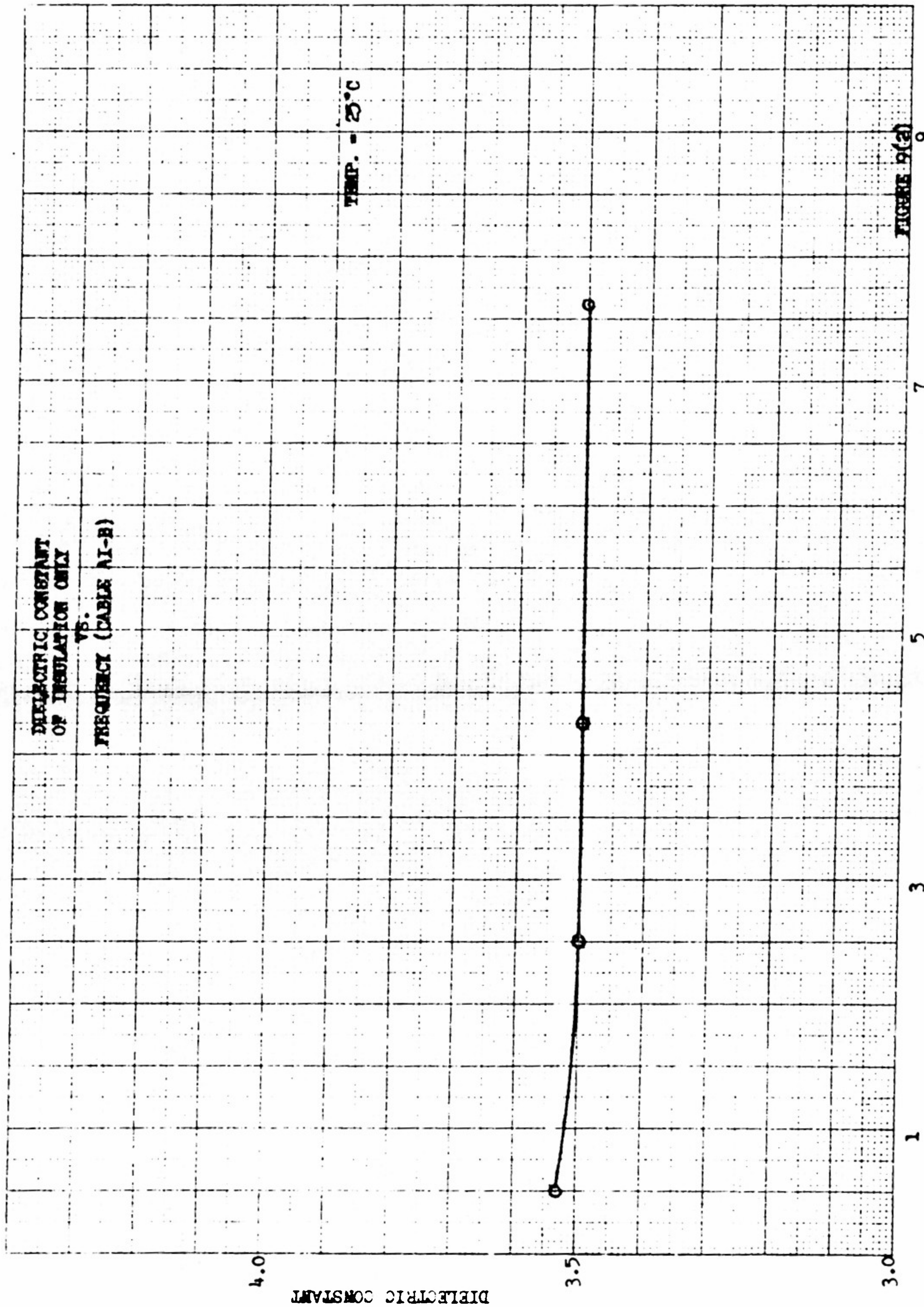
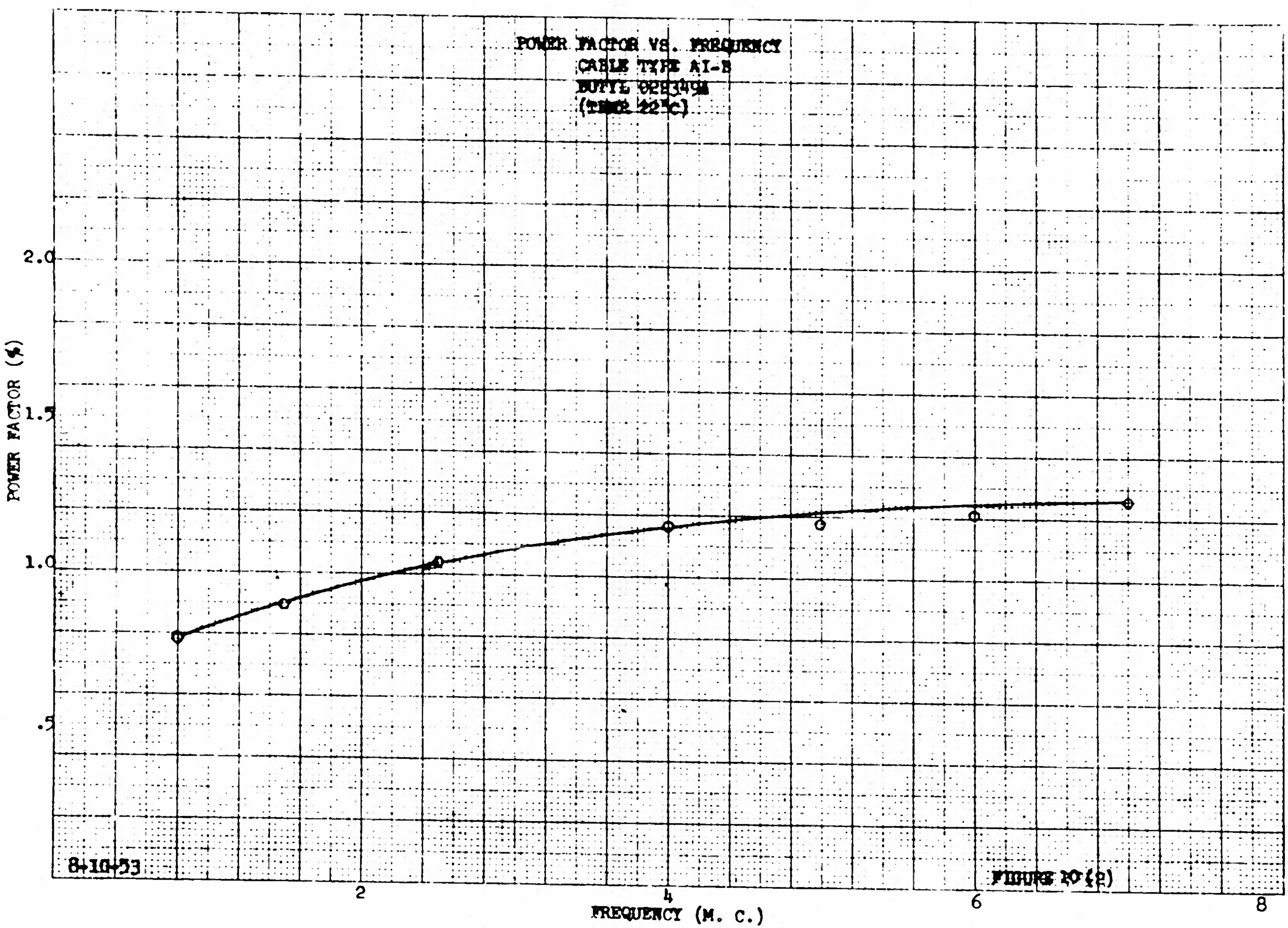
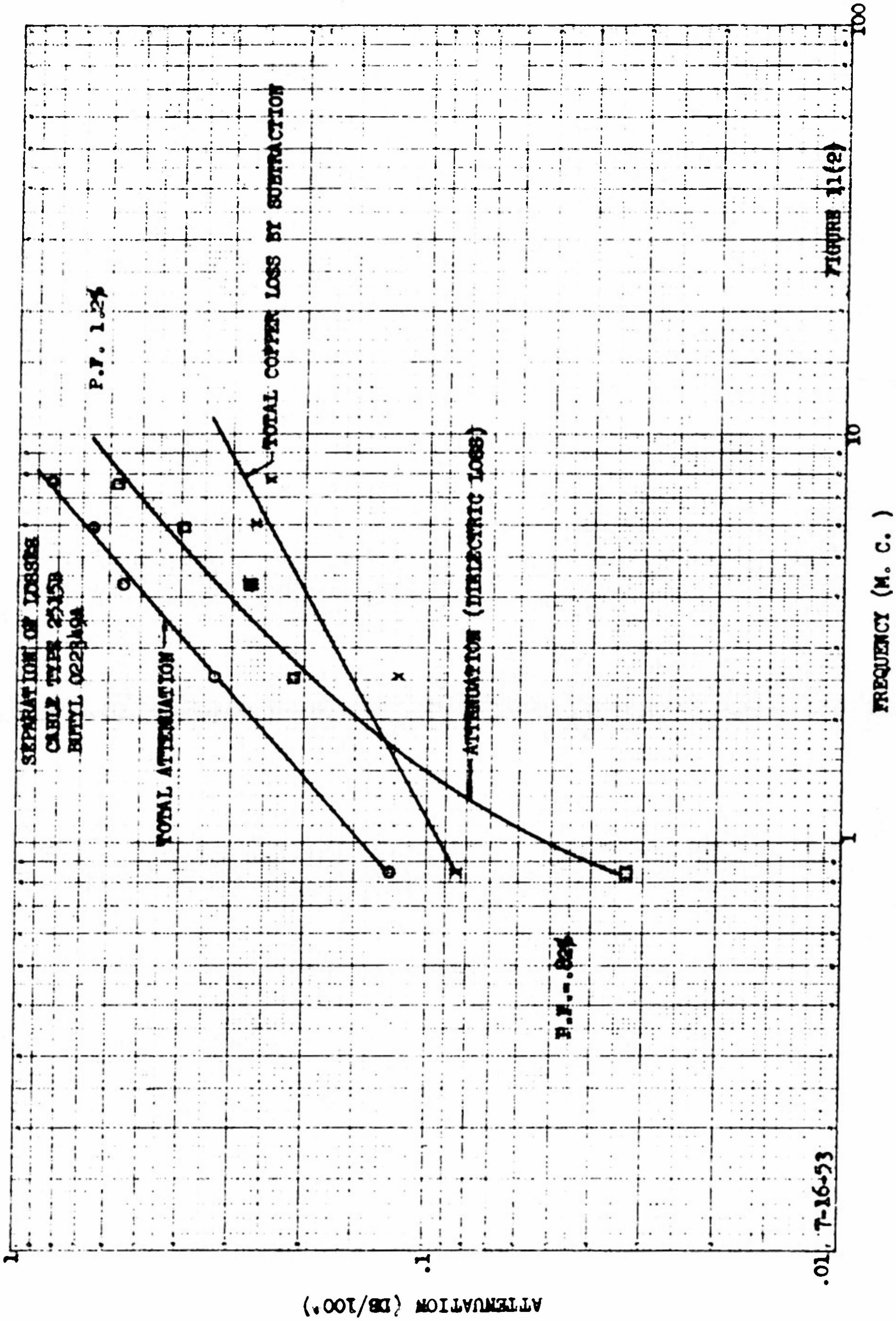

CABLE DIELECTRIC CONSTANT
VS.
FREQUENCY
TYPE AI-B
022349A BUTYL
CABLE
TEMP. = 25°C
DIELECTRIC CONSTANT
4.0
3.9
3.8
3.7
3.5
1
2
3
4
5
6
8
FREQUENCY (M.C.)
7-30-53

FIGURE 8(2)


DIELECTRIC CONSTANT
OF INSULATION ONLY
VS.
FREQUENCY (CABLE AI-B)
TEMP. = 25°C
DIELECTRIC CONSTANT
4.0
3.5
3.0
FREQUENCY (M.C.)
1
3
5
7
9
FIGURE 9(a)


POWER FACTOR VS. FREQUENCY
CABLE TYPE AI-B
BUTYL 023494
(TEMP. 22°C)
POWER FACTOR (%)
2.0
1.5
1.0
.5
FREQUENCY (M. C.)
2
4
6
8
8-10-53
FIGURE 10 (2)


SEPARATION OF LOSSES
TOTAL ATTENUATION
ATTENUATION (DIELECTRIC LOSS)
TOTAL COPPER LOSS BY SUBTRACTION
FIGURE 11(2)
7-16-53
1
.1
.01
10
100
ATTENUATION (DB/100')
FREQUENCY (M. C.)

CORONA DETECTION

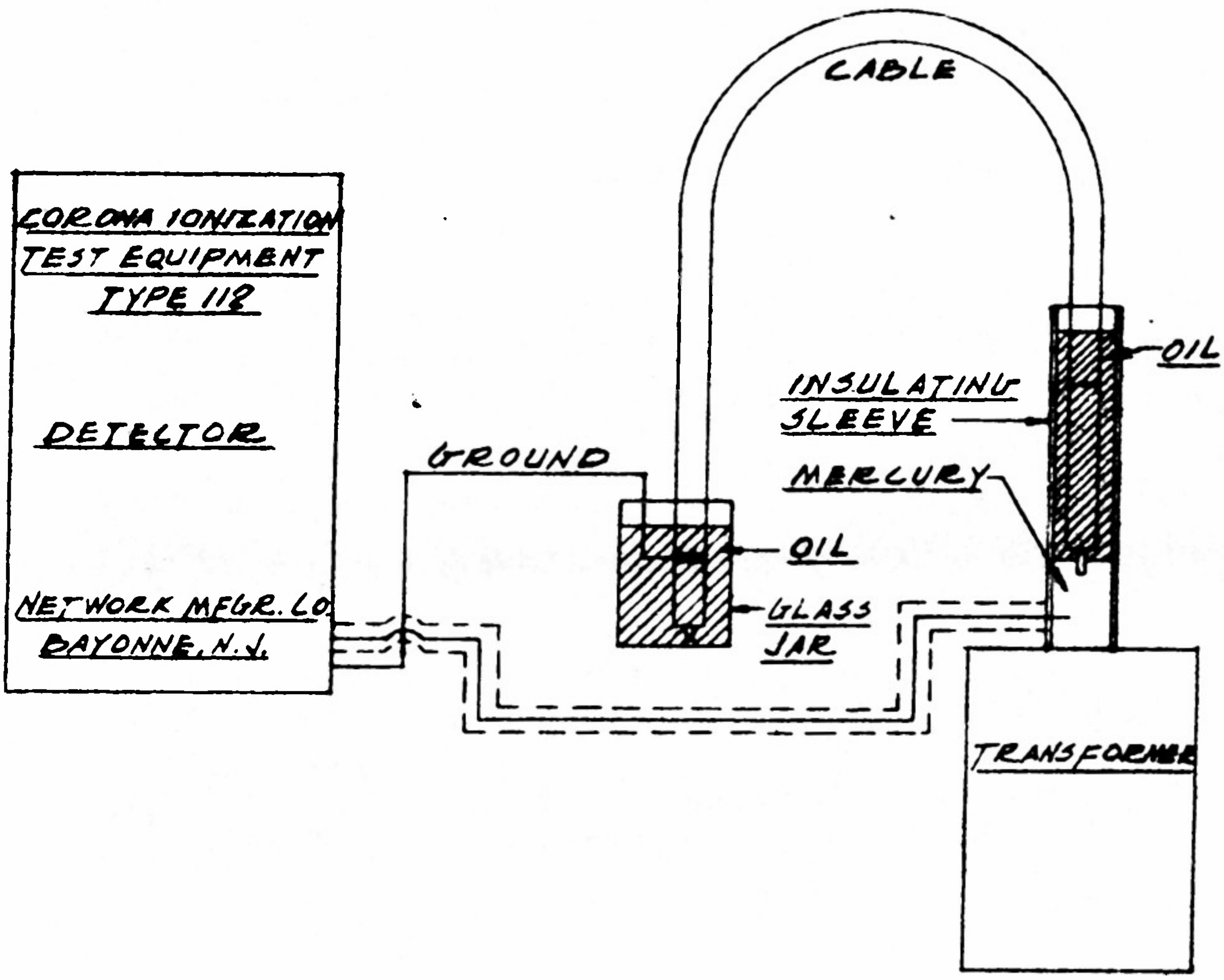


FIG. 12 (2)

THE OKONITE COMPANY AND THE OKONITE-CALLENDER CABLE CO. INC. PASSAIC, N. J., U. S. A.	DATE 9-11-55	SCALE	REVISIONS
	DR.	TR.	DRAWING NO. D-3980
	CH.	APP.	

POWER RATING SETUP
(60 CYCLES)

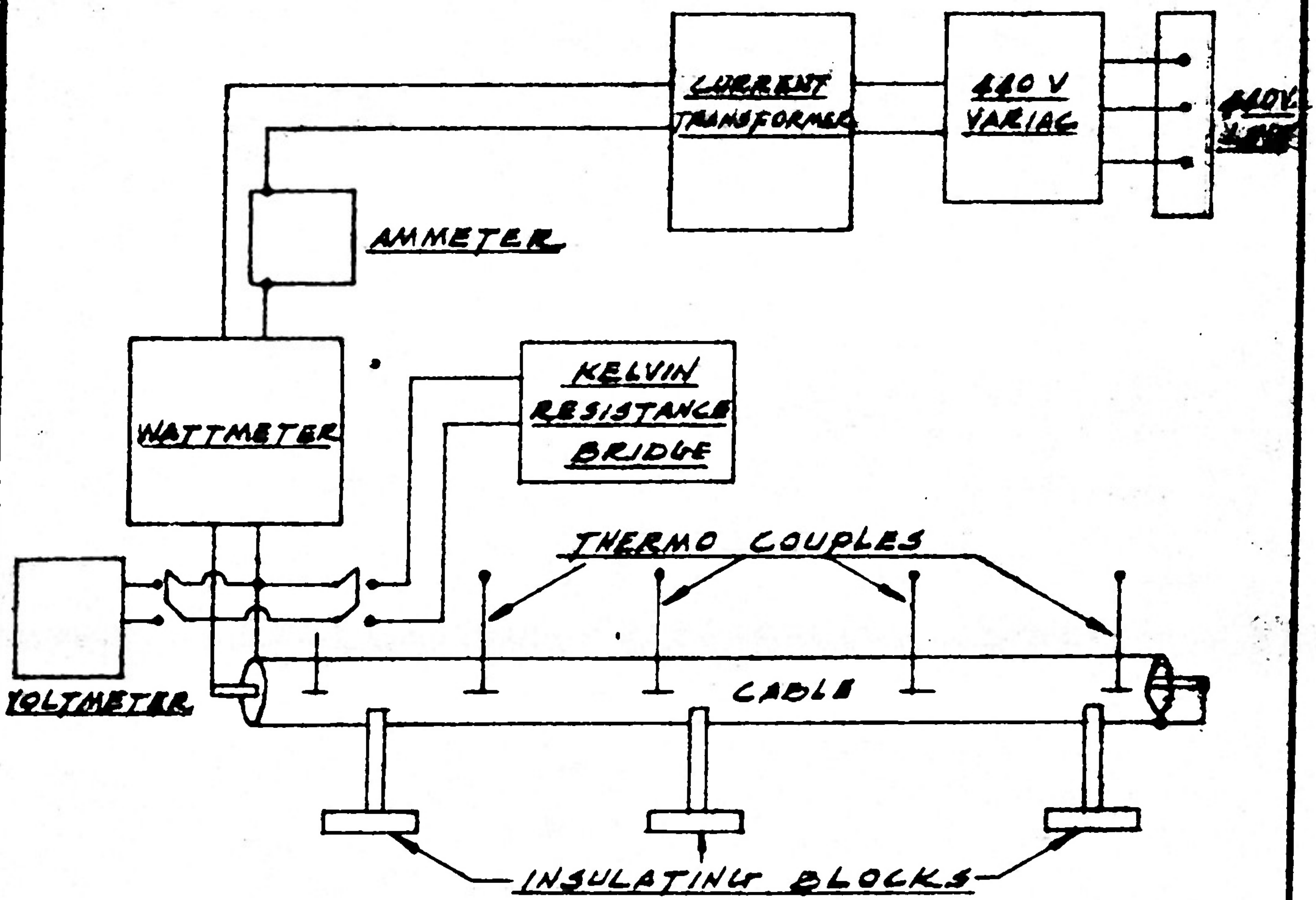
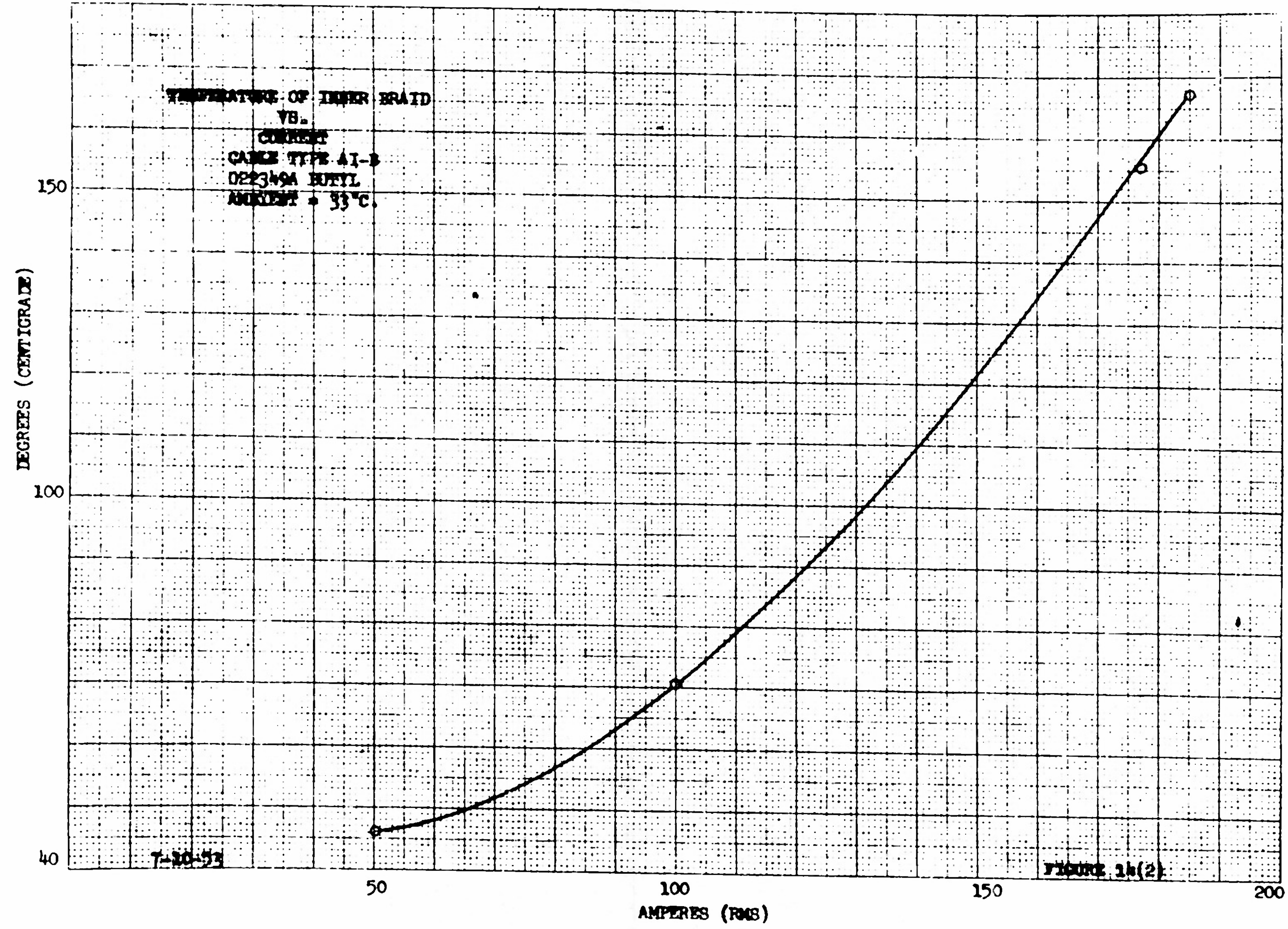
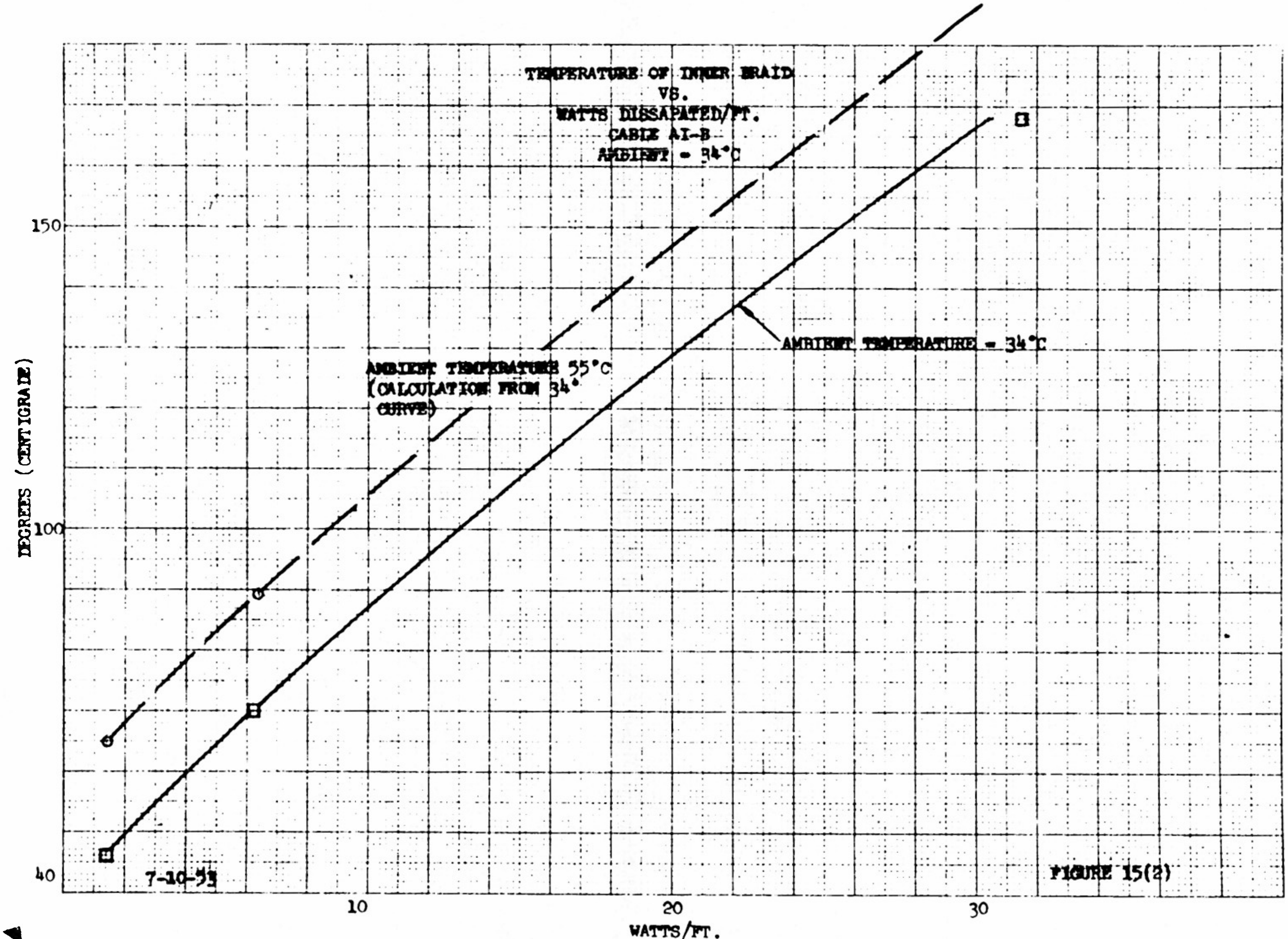


FIG. 13 (2)

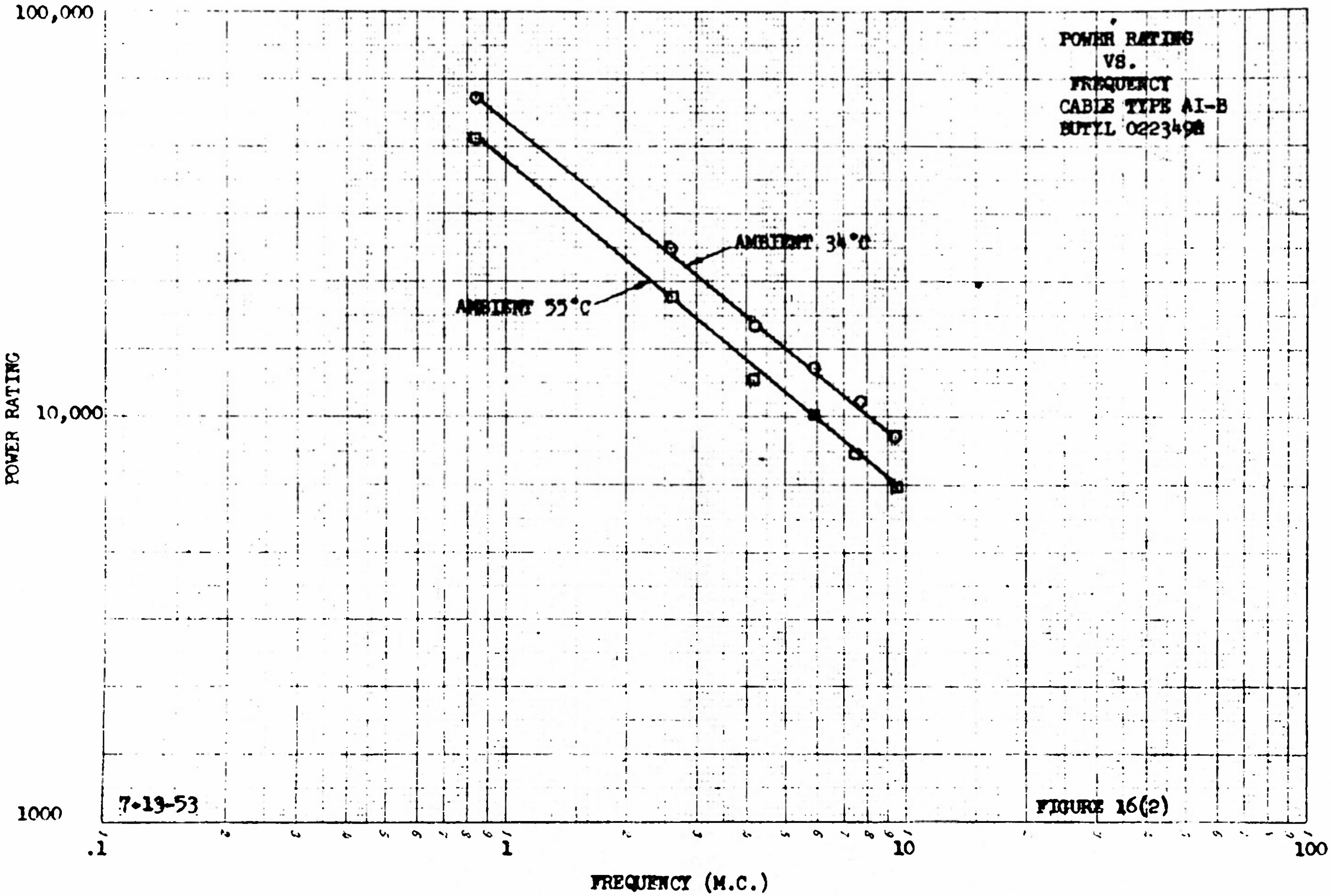
THE OKONITE COMPANY AND THE OKONITE - CALLENDER CABLE CO. INC. PASSAIC, N. J., U. S. A.	DATE 9-11-53	SCALE	REVISIONS
	DR. BJW	TR.	DRAWING NO. D-3981
	CH.	APP.	


TEMPERATURE OF INNER BRAID
VS.
CURRENT
CABLE TYPE AI-B
022349A BUTYL
AMBIENT = 33°C.
DEGREES (CENTIGRADE)
40
100
150
AMPERES (RMS)
50
100
150
200
7-20-53
FIGURE 14(2)



TEMPERATURE OF INNER BRAID
VS.
WATTS DISSAPATED/FT.
CABLE AI-B
AMBIENT = 34°C
AMBIENT TEMPERATURE = 34°C
AMBIENT TEMPERATURE 55°C
(CALCULATION FROM 34°
CURVE)
DEGREES (CENTIGRADE)
150
100
40
10
20
30
WATTS/FT.
7-10-53

FIGURE 15(2)


POWER RATING
VS.
FREQUENCY
CABLE TYPE AI-B
BUTYL 0223498
AMBIENT 34°C
AMBIENT 55°C
100,000
10,000
1000
POWER RATING
.1
1
10
100
FREQUENCY (M.C.)
7-13-53
FIGURE 16(2)

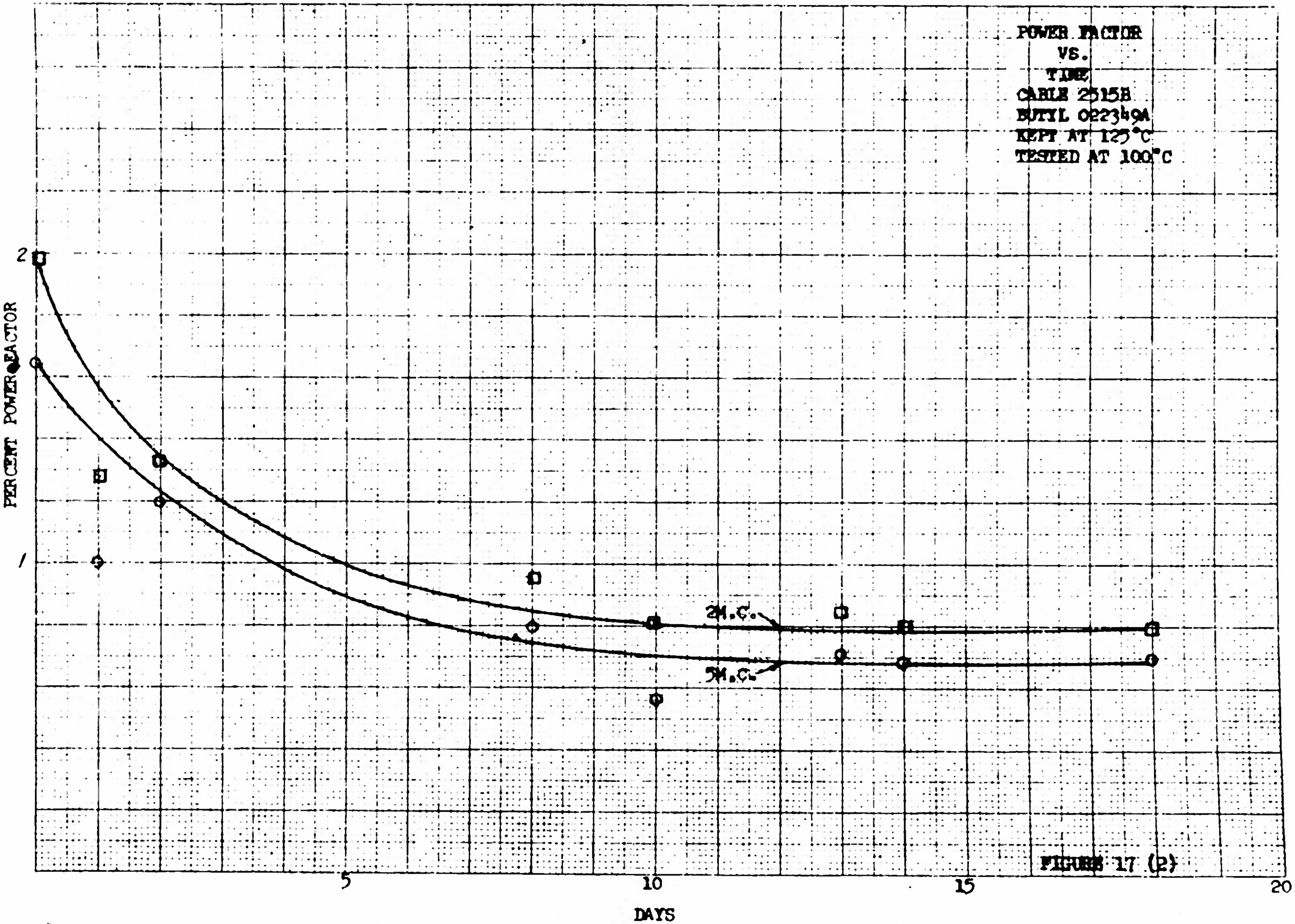
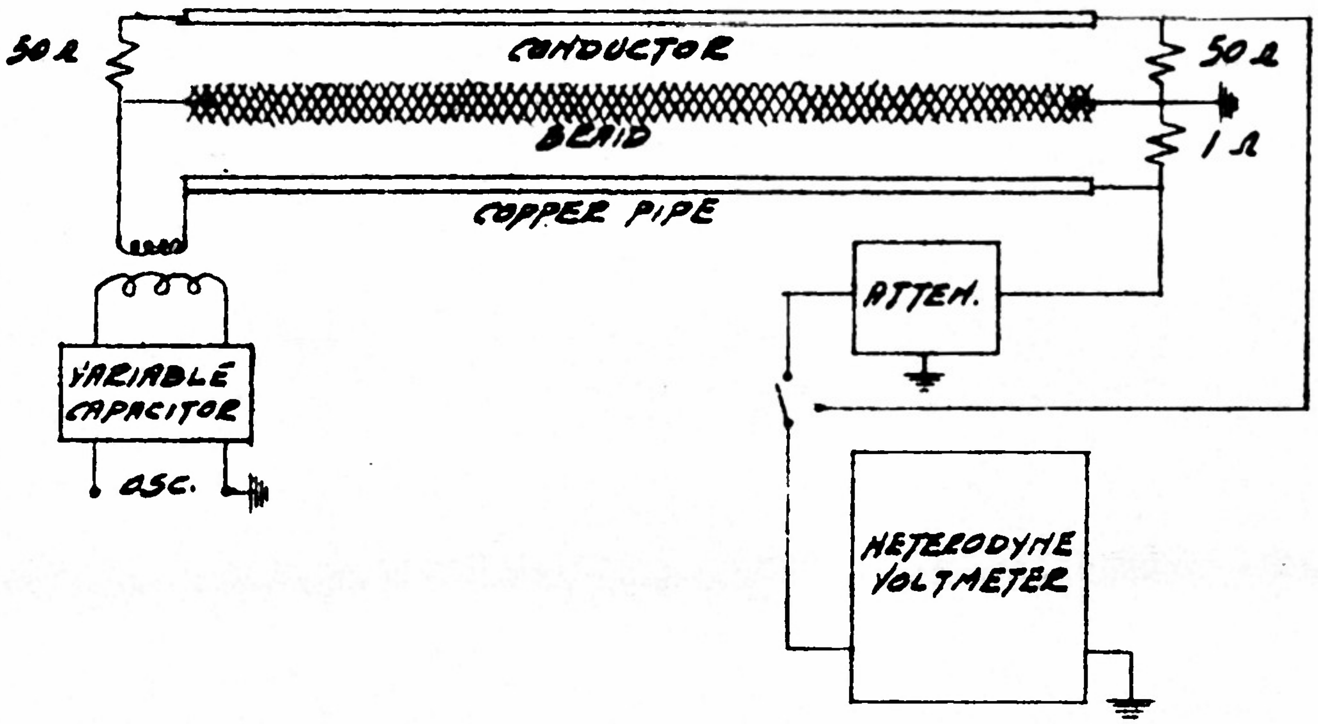

POWER FACTOR
VS.
TIME
CABLE 2515B
BUTYL 022349A
KEPT AT 125°C
TESTED AT 100°C
PERCENT POWER FACTOR
2
1
2M.C.
5M.C.
5
10
15
20
DAYS

FIGURE 17 (2)

Z α β TEST CIRCUIT #1

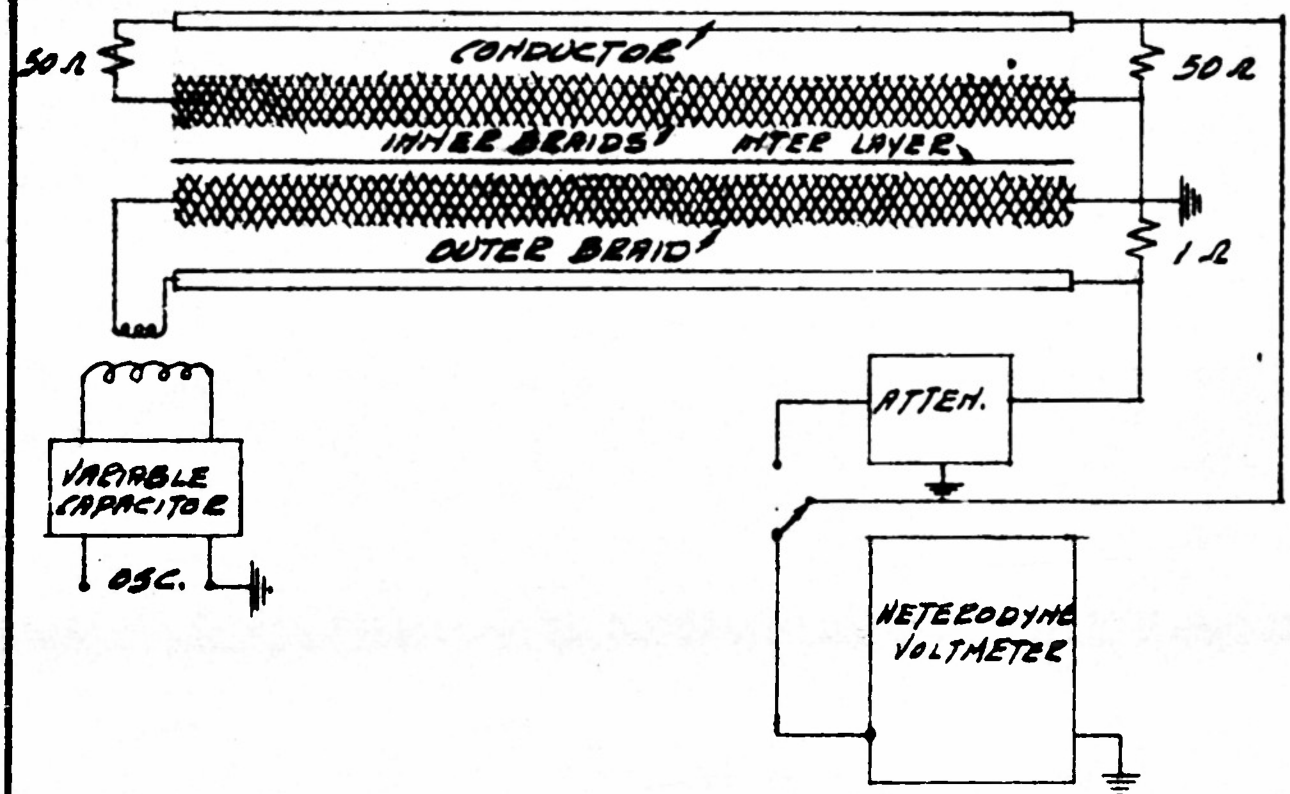


GENERAL RADIO 1330 A BRIDGE OSC.
DAVEN 050-50 VARIABLE ATTEN.
BRUEN & KJAER HETERODYNE VOLT.
ALL RESISTANCES ARE GENERAL RADIO TYPE HIGH FREQUENCY RESISTORS

FIGURE 18 (2)

THE OKONITE COMPANY AND THE OKONITE-CALLENDER CABLE CO. INC. PASSAIC, N. J., U. S. A.	DATE 9-11-53	SCALE —	REVISIONS
	DR. DVD	TR.	DRAWING NO. D-3978
	CH.	APP.	

Z α β TEST CIRCUIT #2



GENERAL RADIO 1330A BRIDGE OSC.

DAVEN 650-50 VARIABLE ATTEN.

BRUEN & KJAER HETERODYNE VOLTMETER

ALL RESISTORS ARE GENERAL RADIO TYPE HIGH FREQUENCY RESISTORS

FIGURE 19 (2)

THE OKONITE COMPANY AND THE OKONITE-CALLENDER CABLE CO. INC. PASSAIC, N. J., U. S. A.	DATE 9-11-53 DR. DVD CH.	SCALE — TR. APP.	REVISIONS DRAWING NO. D-3979

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2. Reports from Airtron, Inc. on Contract W-33-038 AC 17153 Interim Report III.

3. Dow Corning Bulletin. Technical Data DC 80 Silicone Rubber Bulletin 9-325, March 1953.

4. Bell Laboratories Report. Crosstalk Between Coaxials. File 36676-5, September 23, 1946 - 3430 - EFV-HH